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Form Approved  
OMB No. 0704-0188

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T DATE

3. REPORT TYPE AND DATES COVERED

00/00/82

## 4. TITLE AND SUBTITLE

INDUSTRIAL HYGIENE SPECIAL STUDY NUMBER 55-35-0125-83, EVALUATION OF POTENTIAL EXPOSURES HYDRAZINE BLENDING FACILITY, ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, COLORADO

## 5. FUNDING NUMBERS

## 6. AUTHOR(S)

## 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

ARMY ENVIRONMENTAL HYGIENE AGENCY  
ABERDEEN PROVING GROUND, MD

## 8. PERFORMING ORGANIZATION REPORT NUMBER

86280R02

## 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

## 10. SPONSORING/MONITORING AGENCY REPORT NUMBER

DTIC  
ELECTE  
NOV 1 0 1994

250 94-34868

## 11. SUPPLEMENTARY NOTES



## 12a. DISTRIBUTION/AVAILABILITY STATEMENT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

## 12b. DISTRIBUTION CODE

## 13. ABSTRACT (Maximum 200 words)

THIS STUDY WAS CONDUCTED TO QUANTIFY WORKER EXPOSURES TO NDMA, UDMH, AND HYDRAZINE IN THE HYDRAZINE BLENDING FACILITY, AS REQUIRED FOR PHASE I FACILITY CLEANUP AND DECONTAMINATION.

AIR SAMPLES FOR UDMH AND HYDRAZINE WERE BELOW LEVELS OF ANALYTICAL SENSITIVITY. AIR SAMPLES FOR NDMA WERE ABOVE THE REGULATORY LIMIT.

DTIC QUALITY INSPECTED 8

## 14. SUBJECT TERMS

AIR MONITORING, UDMH

## 15. NUMBER OF PAGES

## 16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT  
UNCLASSIFIED

## 18. SECURITY CLASSIFICATION OF THIS PAGE

## 19. SECURITY CLASSIFICATION OF ABSTRACT

## 20. LIMITATION OF ABSTRACT

86280R02  
2nd Copy

**UNITED STATES ARMY  
ENVIRONMENTAL HYGIENE  
AGENCY**

**ABERDEEN PROVING GROUND, MD 21010**

INDUSTRIAL HYGIENE SPECIAL STUDY NO. 55-35-0125-83  
EVALUATION OF POTENTIAL EXPOSURES  
HYDRAZINE BLENDING FACILITY, ROCKY MOUNTAIN ARSENAL  
COMMERCE CITY, COLORADO  
7-17 DECEMBER 1982

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DEPARTMENT OF THE ARMY Mr. Graham/or1/AUTOVON  
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY 584-3118  
ABERDEEN PROVING GROUND, MARYLAND 21010

REPLY TO  
ATTENTION OF  
HSHB-01-F/WP

31 AUG 1983

SUBJECT: Industrial Hygiene Special Study No. 55-35-0125-83, Evaluation of Potential Exposures, Hydrazine Blending Facility, Rocky Mountain Arsenal, Commerce City, Colorado, 7-17 December 1982

Commander  
US Army Materiel Development  
and Readiness Command  
ATTN: DRCSG  
Alexandria, VA 22333

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### EXECUTIVE SUMMARY

The purpose, essential findings, and major recommendations of the inclosed report follow:

a. Purpose. To quantify worker exposures to N-Nitrosodimethylamine (NDMA), 1,1-Dimethylhydrazine (UDMH) and hydrazine in the Hydrazine Blending Facility, Rocky Mountain Arsenal (RMA).

b. Essential Findings. Findings are based on sample results which have previously been provided to RMA. Analyses for UDMH and hydrazine were conducted onsite and results were left with RMA personnel. Contractual agreement was used to provide NDMA sample results directly to RMA.

(1) Air samples for UDMH and hydrazine were below levels of analytical sensitivity.

(2) Air samples for NDMA, (a regulated suspect carcinogen) showed levels in excess of the regulatory limit throughout the Hydrazine Blending Facility.

c. Major Recommendations.

(1) Provide and insure the continued use of full body protective clothing.

(2) Provide and insure the continued use of full facepiece, positive pressure, atmosphere supplying respirators for any entry or operation to be performed in the Hydrazine Blending Facility.

FOR THE COMMANDER:

1 Incl  
as (10 cy)

*for* *Richard W. Gaydos*  
JOEL C. GAYDOS, M.D.  
Colonel, MC  
Director, Occupational and  
Environmental Health

CF:  
HQDA (DASG-PSP) wo Incl  
Cdr, DARCOM (DRCSF-E)  
Cdr, AMCCOM [DRSMC-SG(R)]  
Cdr, HSC (HSPA-P)  
Comdt, AHS (HSHA-IPM)  
Cdr, RMA (2 cy)  
Cdr, FAMC (PVNTMED Actv) (2 cy)  
C, USAEMA-Rgn Div West



DEPARTMENT OF THE ARMY  
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY  
ABERDEEN PROVING GROUND, MARYLAND 21010

DEPLY TO  
ATTENTION 00

MSHB-01-F/WP

INDUSTRIAL HYGIENE SPECIAL STUDY NO. 55-35-0125-83  
EVALUATION OF POTENTIAL EXPOSURES  
HYDRAZINE BLENDING FACILITY, ROCKY MOUNTAIN ARSENAL  
COMMERCE CITY, COLORADO  
7-17 DECEMBER 1982

1. AUTHORITY. Letter, DRCSG-0, HQ DARCOM, 6 August 1982, subj: Hydrazine Facility - Abatement Plan Implementation, and attached inclosures.
2. REFERENCES. Refer to Appendix A for a listing of references used in this report.
3. ABBREVIATIONS. A glossary of technical terms and abbreviations used in this report is included as Appendix B.
4. PURPOSE. This study was conducted to quantify worker exposures to NDMA, UDMH and hydrazine in the Hydrazine Blending Facility, RMA, as required for Phase I, Facility Clean up and Decontamination (Refer to references 5 and 6, Appendix A).
5. BACKGROUND.
  - a. The Hydrazine Blending Facility, RMA, has been identified as containing, through airborne release, varying amounts of NDMA, a regulated suspect carcinogen (refer to references 2, 3, 4 and 7, Appendix A). The OSHA interpretation of the NDMA release and potential worker exposure constitutes violation of Title 29, CFR Part 1910.1016, N-Nitrosodimethylamine (refer to references 1 and 4, Appendix A). Phase I - Facility Clean up and Decontamination (refer to references 5 and 6, Appendix A) requires elimination of known and potential airborne sources of NDMA with follow-up air monitoring by this Agency. The ultimate goal of the hazard abatement plan is to allow personnel to enter the Hydrazine Blending Facility for routine visual inspections without necessity for SCBA. The use of SCBA and/or other supplied air devices is deemed necessary for operations involving blending and transfer.
  - b. All samples collected during this survey were general area samples. No operations were ongoing, nor were operating personnel present by study design.
  - c. The survey was conducted by 1LT Joseph B. Silkowski, MSC; Mrs. Susie W. Lynn, DAC; and Mr. Stephan C. Graham (P.O.), DAC, IHD. Analysis of hydrazine and UDMH samples was provided by Mr. George Podolak, DAC, Organic Environmental Chemistry Division, this Agency.

Use of trademarked names does not imply endorsement by the US Army, but is intended only to assist in identification of a specific product.

d. The current OSHA 8-hour PEL for hydrazine and UDMH established by 29 CFR 1910.1000, Air Contaminants, (Reference 1, Appendix A) is 1.0 ppm or 1.3 mg/m<sup>3</sup> (1300 ug/m<sup>3</sup>) of air and 0.5 ppm or 1.0 mg/m<sup>3</sup> (1000 ug/m<sup>3</sup>), respectively, with skin notation. The criteria recommended by the ACGIH (refer to reference 8, Appendix A) for hydrazine and UDMH is 0.1 ppm or 0.13 mg/m<sup>3</sup> (130 ug/m<sup>3</sup>) and 0.5 ppm or 1.0 mg/m<sup>3</sup> (1000 ug/m<sup>3</sup>), respectively, with "Skin" notation, as 8-hour TWA's. The legally enforceable levels of worker exposure are those stipulated in 29 CFR 1910, Occupational Safety and Health Standards. The recommended criteria of the ACGIH, although not legally enforceable, does represent the latest consensus of the ACGIH based on current scientific literature and philosophy. The ACGIH has placed hydrazine and UDMH in the group of industrial substances suspected of possessing carcinogenic potential for man (Refer to Appendix C, Occupational Exposure Standards and Criteria).

e. The current OSHA PEL for NDMA is "No detectable levels" per 29 CFR 1910.1016, N-Nitrosodimethylamine (Refer to Appendix C, Occupational Exposure Standards and Criteria).

## 6. PROCEDURE.

### a. Hydrazine and UDMH.

(1) General area samples were taken to determine the atmospheric concentration of hydrazine and UDMH. DuPont® Constant Flow Samplers, Model P4000 or MSA® Air Samplers, Model G, both calibrated for 1.0 Lpm, were used for sampling. Pumps were calibrated daily and adjusted as necessary. Collecting media consisted of 250 mg of 40/60 mesh activated silica gel coated with concentrated sulfuric acid (20 percent by weight). Samples were collected at specific sites as "Repeated Samples" using 250 mg of 40/60 mesh firebrick coated with concentrated sulfuric acid (20 percent by weight). Sampling times varied from 120 to 167 minutes.

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\* "Skin" notation as defined by the ACGIH refers to the potential contribution to the overall exposure by the cutaneous route including mucous membranes and eyes, either by airborne, or more particularly, by direct contact with the substance. This designation is intended to suggest appropriate measures for prevention of cutaneous absorption so that the threshold limit is not invalidated.

• DuPont is a registered trademark of E. I. DuPont de Nemours and Co., Inc., Wilmington, Delaware.

• MSA is a registered trademark of Mine Safety Appliance Company, Pittsburgh, Pennsylvania.

(2) Repeated samples using firebrick media were collected at specific sites because moisture in silica gel tubes was observed to freeze in cold temperatures. The freezing of moisture in the silica gel tubes caused an increased resistance to air flow and possible reduction of collection sites for contaminants on the silica gel media.

(3) The analytical scheme consisted of: elution of samples from the sorbent with distilled water; formation of derivatives by the addition of 2-furaldehyde in sodium acetate solution; extraction of derivatives in ethyl acetate; and measurement by gas chromatography. The instrumentation used for analysis consisted of a Hewlett-Packard® 3800 Gas Chromatograph.

(4) Wipe samples of specific work area surfaces and equipment were collected to qualitate the effectiveness of Phase I clean up procedures. Wipe samples were collected using Whatman® Ashless Quantitative Grade Filter Paper (12.5 cm). Samples represented a surface area of approximately one square foot. The analytical procedure consisted of desorption with 0.4 molar sulfuric acid solution and analysis by liquid chromatography.

b. NDMA.

(1) General area samples were taken to determine the atmospheric concentration of NDMA. Samples were taken concurrently at locations used for hydrazine and UDMH sampling. DuPont Constant Flow Samplers, Model P4000 or MSA Air Samplers, Model G, both calibrated for 1.0 Lpm, were used for sampling. Pumps were calibrated daily and adjusted as necessary. The collection device used was a commercial Thermo Sorb/N® Air Sampler (refer to reference 10, Appendix A). Sampling times varied from 120 to 186 minutes.

(2) Analysis of NDMA samples was provided by Thermo Electron Corporation, Waltham, Massachusetts through contractual agreement with RMA. Results were provided to this Agency (refer to reference 7, Appendix A).

c. Quality Control. Quality control samples were provided by the Environmental Division, RMA for hydrazine, UDMH and NDMA.

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- Hewlett-Packard is a registered trademark of Hewlett Packard Company, Avondale Division, Avondale, Pennsylvania.
  - Whatman is a registered trademark of Whatman Chemical Separation, Inc., Clifton, New Jersey, a subsidiary of Whatman Chemical Separation, Limited, England.
  - ThermoSorb/N Air Sampler is a registered trademark of Thermo Electron Corporation, Waltham, Massachusetts.

## 7. FINDINGS AND DISCUSSION.

a. General area samples were collected at specific work locations based on known or potential hydrazine, UDMH and/or NDMA release or contamination. Figure, Appendix D, Diagram of Hydrazine Blending Facility and Sampling Points, shows the basic facility layout with identified sampling locations. Table D-1, Appendix D, Sampling Points, presents a narrative description of the specific sampling locations. Table D-2, Appendix D, Samples Collected Per Sampling Site, identifies the number of samples collected per sampling location including repeated samples. Appendix E, Weather Conditions During Sampling Periods, presents the approximate temperature, humidity and barometric pressure during sampling.

b. Results of sampling are present in: Table F-1, Appendix F, Results of Analyses of Atmospheric Samples, Table F-2, Appendix F, Results of Wipe Samples for Hydrazine and Unsymmetrical Dimethylhydrazine; and, Table F-3, Appendix F, Results of Analyses of Quality Control Samples for N-Nitrosodimethylamine Submitted by Rocky Mountain Arsenal to Thermo Electron Corporation, Analytical Instrument Division, Waltham, Massachusetts. Results are presented in  $\text{ug}/\text{m}^3$ . The analytical limits of detection of general area samples for hydrazine, UDMH and NDMA were 0.05, 0.10, and 0.05  $\text{ug}/\text{m}^3$ , respectively. The analytical limits of detection of wipe samples for hydrazine and UDMH were 5  $\text{ug}$  and 0.2  $\text{ug}$ , respectively. Sample results reported as "less than" the comparative detection limit are based on the limits of sampling and analytical methodology, and may not represent the actual presence of contaminant.

c. All general area hydrazine and UDMH samples were below the detectable limits of analysis (refer to Table F-1, Appendix F).

d. Wipe samples for hydrazine and UDMH identified the drum loading station filling nozzles and connectors as being a source of contact contamination. The control panel of the mixing and blending area, and the electrical outlet north of Tank HAS-1 showed relatively low levels of UDMH contamination. The use of wipe sample results is only to qualitate contaminant locations.

e. Results of NDMA sampling demonstrated that all work areas had some degree of detectable contamination. The blending and mixing area had NDMA contamination ranging from none detected to 20.0  $\text{ug}/\text{m}^3$  (SP-22, SP-9, 10 & 11); the waste sump ranged from none detected to 2.6  $\text{ug}/\text{m}^3$  (SP-3, 4, 5 and 6); the drum storage area ranged from 1.0 to 1.4  $\text{ug}/\text{m}^3$  (SP-21); the interior of Building 759 ranged from 1.3 to 1.7  $\text{ug}/\text{m}^3$  (SP-7); the tank storage area ranged from 0.5 to 4.7  $\text{ug}/\text{m}^3$  (SP-12 thru 16 and 20); the east area tank facility ranged from trace levels to 0.62  $\text{ug}/\text{m}^3$  (SP-17, 18 & 19).

f. The total Hydrazine Blending Facility has been assumed to be contaminated with NDMA and workers entering this area have been so protected. Sampling point SP-1, north fence entrance, has been identified as having "trace" amounts of NDMA exposure. This implies that the Personnel Change Facility Trailer located within 50 feet of this point may not be located to protect the workers from potential NDMA exposure. The specific source(s) of the NDMA contamination could not be determined, but it can be assumed that the prevailing winds from the facility carry NDMA from contamination sources from within the facility. Workers entering the Personnel Change Facility Trailer may be carrying NDMA contamination on their protective clothing following operations within the facility. Potential, therefore, exists for NDMA exposure within the change trailer from protective clothing removal.

#### 8. CONCLUSION.

a. There were no sources of detectable quantities of hydrazine or UDMH contamination identified by air sampling.

b. Wipe sampling identified the drum loading station filler nozzles and connectors, the control panel of the mixing and blending area, and the electrical outlet north of Tank HAS-1 as sites of potential hydrazine/UDMH contact exposure.

c. Detectable quantities of NDMA were present, as air contaminants, throughout the Hydrazine Blending Facility.

d. Potential exists for worker exposure to "detectable amounts" of NDMA at the Personnel Change Facility Trailer located approximately 50 feet from the north fence entrance (SP-1).

9. RECOMMENDATIONS. The following recommendations are based on requirements of OSHA Regulation 29 CFR 1910.1016 and good industrial hygiene practice. The issue of the applicability of the scope of 29 CFR 1910.1016 to the Blending Facility will not be addressed in this study. Good industrial hygiene practice relates to reasonable and prudent measures deemed necessary based on the views of the ACGIH that UDMH and hydrazine have carcinogenic potential.

a. Provide and insure the continued use of personal protective full body clothing to prevent skin contact with potentially contaminated NDMA, UDMH and/or hydrazine work surfaces. Continue to provide levels of protective clothing based on the specific types of activities or operations to known or possible NDMA, UDMH and/or hydrazine exposure as presented in reference 4 and 5, Appendix A.

b. Provide and insure the continued use of full facepiece, pressure demand atmosphere supplying respirators (air line, SCBA) for any entry or



operation to be performed in the Hydrazine Blending Facility. The finding of detectable levels of NDMA throughout the Hydrazine Blending Facility during a period of nonoperation, following clean-up procedures, necessitates continued and specific use of atmosphere supplying devices.

c. Provide documentation sampling of potential NDMA exposure inside and around the Personnel Change Facility Trailer. [Note: Sampling assistance may be provided by USAEHA personnel stationed at Fitzsimmons Army Medical Center (USAEHA - Regional Division West, AUTOVON 943-3725/8881).]

10. TECHNICAL ASSISTANCE. Requests for services should be directed through appropriate command channels of the requesting activity to the Commander, US Army Environmental Hygiene Agency, ATTN: HSHB-OI-F, Aberdeen Proving Ground, MD 21010, with an information copy furnished the Commander, US Army Health Services Command, ATTN: HSPA-P, Fort Sam Houston, TX 78234.

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APPE DIX A

REFERENCES

1. Title 29, Code of Federal Regulations (CFR), 1982 rev, Part 1910, Occupational Safety and Health Standards.
2. Letter, HSE-OI/WP, this Agency, 6 February 1980, subject: Industrial Hygiene Special Study No. 55-35-0128-80, N-Nitrosodimethylamine Exposure During Aerozine 50 Transfer Operation, Rocky Mountain Arsenal, Commerce City, CO, 8-13 July 1979.
3. Letter, HSE-MW, this Agency, 28 October 1980, subject: Industrial Hygiene Special Study No. 55-66-0216-81, N-Nitrosodimethylamine, Hydrazine, and 1,1-Dimethylhydrazine Exposures at the Hydrazine Blending Facility, Rocky Mountain Arsenal, Commerce City, Colorado, 16-27 June 1980.
4. Letter, HSHB-OM/WP, this Agency, 28 June 1982, subject: Recommended Actions in Response to OSHA Investigation of Hydrazine Blending and Storage Facility, RMA.
5. Hazard Abatement Plan, Rocky Mountain Arsenal, no date, subject: Rocky Mountain Arsenal Hydrazine Blending and Storage Facility Hazard Abatement Plan.
6. Memorandum for Record, SARRM-TO, Rocky Mountain Arsenal, 3 November 1982, subject: Hydrazine Hazard Abatement Plan Modifications with inclosure.
7. DF, SARRM-TOE, Rocky Mountain Arsenal, 4 February 1983, subject: Hydrazine Facility Monitoring.
8. TLVs® Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1982, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.
9. US Department of Health, Education and Welfare Publication No. 78-172, Criteria for a Recommended Standard, Occupational Exposure to Hydrazines.
10. Instructions for Monitoring, ThermoSorb/N Air Sampler. Thermo Electron Corporation, Analytical Instruments, Waltham, Massachusetts, February 1980.

APPENDIX B

ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
CFR	Code of Federal Regulations
cm	centimeter
DAC	Department of Army Civilian
IHD	Industrial Hygiene Division
Lpm	liter(s) per minute
mg	milligram(s)
mg/m <sup>3</sup>	milligrams per cubic meter of air
MSA	Mine Safety Appliance Company
MSC	Medical Service Corps
NDMA	N-Nitrosodimethylamine
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
PO	Project Officer
ppm	parts per million
RMA	Rocky Mountain Arsenal
SCBA	Self contained breathing apparatus
TLV	Threshold Limit Value
TWA	Time-weighted average
UDMH	1,1-Dimethylhydrazine
ug/m <sup>3</sup>	micrograms per cubic meter of air
USAEHA	US Army Environmental Hygiene Agency

APPENDIX C  
OCCUPATIONAL EXPOSURE STANDARDS AND CRITERIA

SUBSTANCE	OSHA-PEL†			ACGIH-TLV®		
	ppm	mg/m <sup>3</sup>	ug/m <sup>3</sup>	ppm	mg/m <sup>3</sup>	ug/m <sup>3</sup>
1,1-Dimethylhydrazine (UDMH)	0.5	1.0	1000	0.5	1.0	1000
Hydrazine (H)	1.0	1.3	1300	0.1	0.13	130
N-Nitrosodimethylamine (NDMA)	No detectable level			No detectable level		

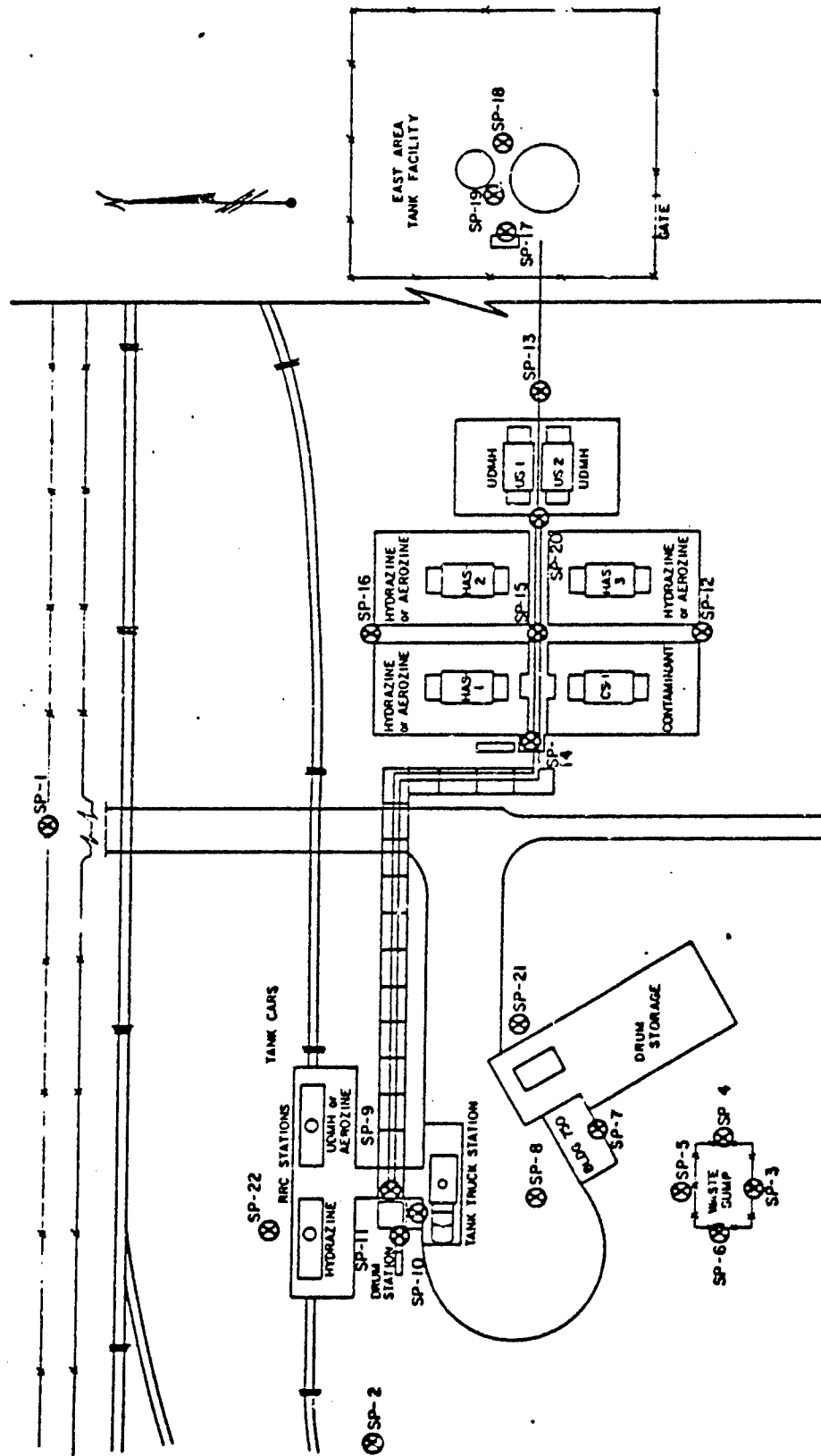
† PEL - Permissible Exposure Limit as an 8-hour time weighted average.

®TLV - Threshold Limit Value is a registered trademark of the American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio. This value is based on an 8-hour time weighted average.

Ind Hygiene Sp Study No. 55-35-0125-83, 7-17 Dec 82

APPENDIX D  
SAMPLING LOCATIONS

D-1



APPENDIX  
SAMPLING POINTS, SP-1 thru SP-22  
9-14 DECEMBER 1982

FIGURE. DIAGRAM OF HYDRAZINE BLENDING  
FACILITY AND SAMPLING POINTS

TABLE D-1. SAMPLING POINTS.

Sampling Point (SP)	Location Description
SP-1	<u>7th Street Fence.</u> Samplers located on the north perimeter fence gate approximately 4 feet above ground level.
SP-2	<u>West Perimeter Fence.</u> Samplers located on the outer perimeter railroad track gate approximately 5 ft above ground level.
	<u>Sump Area.</u> Samplers located centrally on the specifically identified sump perimeter fence approximately 3.5 ft above ground level.
SP-3	south fence
SP-4	east fence
SP-5	north fence
SP-6	west fence
SP-7	<u>Building 759.</u> Sampler located inside Building 759 along southeast wall on workbench approximately 4.5 ft above floor level.
SP-8	<u>Drum Steamout.</u> Sampler located on drum steamout pad approximately midway between Building 759 and Tank Truck Station at a height of 8 inches above ground level.
	<u>Drum Station.</u>
SP-9	1. Sampler located at base on control panel approximately 2 feet above ground level.
SP-10	2. Sampler located on structural support member between Tank Truck Station and Drum Station approximately 5 feet above ground level.
SP-11	3. Sampler located next to drum weighing/filling scale approximately 3 feet above the work surface.

Sampling Point (SP)	Location Description
<u>Tank Storage Area.</u>	
1. Samplers located on specifically identified spill retaining walls of tank storage area approximately 3.5 feet above walkway surfaces.	
SP-12	south wall midway between Tanks CS-1 and HAS-3
SP-13	east wall midway between Tanks US-1 and US-2.
SP-14	west wall midway between Tanks HAS-1 and CS-1.
SP-16	north wall midway between Tanks HAS-1 and HAS-2.
SP-20	west wall of retaining area for Tanks US-1 and US-2.
SP-15	2. Samplers located above tanks on catwalk approximately 15 feet above walkway surface, attached an additional 3.5 feet above catwalk on guardrail.
<u>East Area Tank Facility.</u>	
SP-17	1. Sampler located on scrubber structural support member approximately 4 feet above ground level.
SP-18	2. Sampler located approximately 10 feet east of mid-centerline between storage tanks at a height approximately 2 feet above ground level.
SP-19	3. Sampler located on grate of pump pit between storage tank approximately 2 feet above ground level.
SP-21	<u>Drum Storage Area.</u> Sampler located approximately 20 feet northeast of Building 759 approximately 5 feet above ground level.
SP-22	<u>Railroad Tankcar Loading/Unloading Area.</u> Sampler located north of rail cars approximately 5 feet from track at a height approximately 5 feet above ground level.
<u>Controls.</u>	
SP-FH	1. Sampler located approximately 20 feet southeast of Rocky Mountain Arsenal Firehouse approximately 3.5 feet above ground level.
SP-HQ	2. Sampler located on incinerator 150 feet north of Rocky Mountain Arsenal Headquarters building at a height of approximately 8 feet above ground level.



TABLE D-2. SAMPLES COLLECTED PER SAMPLE SITE.

Sampling Point	Location	Numbers of Samples Collected	
		NDMA*	H and UDMH†
SP-1	Main Gate	2	3 (one repeat)
SP-2	West Gate	2	2
SP-3	Waste Sump	4	5 (one repeat)
SP-4	Waste Sump	4	5 (one repeat)
SP-5	Waste Sump	4	5 (one repeat)
SP-6	Waste Sump	4	5 (one sample broken one repeat)
SP-7	Building 759	2	2
SP-8	Drum Steamout	2	2
SP-9	Drum Station	4	4
SP-10	Drum Station	4	5 (one repeat)
SP-11	Drum Station	4	5 (one repeat)
SP-12	Tank Storage Area	2	2
SP-13	Tank Storage Area	2	2
SP-14	Tank Storage Area	2	2
SP-15	Tank Storage Area	2	2
SP-16	Tank Storage Area	2	2
SP-17	East Area Tank Facility	2	2
SP-18	East Area Tank Facility	2	2
SP-19	East Area Tank Facility	2	2
SP-20	Tank Storage	2	2
SP-21	Drum Storage	4	5 (one repeat)
SP-22	North Side Railcars	4	5 (one repeat)
SP-FH	Control - Firehouse	2	3 (one repeat)
SP-HQ	Control - Headquarters	2	3 (one repeat)

\* NDMA - N-Nitrosodimethylamine

† H - Hydrazine, UDMH - 1,1-Dimethylhydrazine

Ind Hygiene Sp Study No. 55-35-0125-83, 7-17 Dec 82

APPENDIX E  
WEATHER CONDITIONS\* DURING SAMPLING PERIODS

Date (1982)	Temperature Range in degrees Fahrenheit	Percent Humidity (relative)	Barometric Pressure in inches mercury
Thursday, 9 December	17-23	83	30.22
Friday, 10 December	27-30	80	unknown
Monday, 13 December	24-58	68	29.60
Tuesday, 14 December	35-50	64	29.79

\* Values obtained from local Denver, Colorado television weather reports or hand held survey devices.

APPENDIX F  
SAMPLE RESULTS

TABLE F-1. RESULTS OF ANALYSES OF ATMOSPHERIC SAMPLES

Sampling Point	Date Sampled	Simultaneous Samples		Sample Results			Remarks
		Hyd/UDMA* Sample No.	NDMA+ Sample No.	Hydrazine (in micrograms/cubic meter - ug/m <sup>3</sup> )	UDMH	NDMA (ug/m <sup>3</sup> )	
SP-1	10 Dec 82	SG-47	A0 3489	<0.05	<0.10	ND†	repeated sample
	13 Dec 82	FB-03	A0 3407	<0.05	<0.10	Trace§	
	14 Dec 82	FB-38	--	<0.05	<0.10	--	
SP-2	13 Dec 82	FB-07	A0 3410	<0.05	<0.10	ND	morning sample
	13 Dec 82	FB-09	A0 3486	<0.05	<0.10	ND	afternoon sample
SP-3	9 Dec 82	SG-10	A0 3066	<0.05	<0.10	0.70	
	10 Dec 82	SG-37	A0 3475	<0.05	<0.10	1.70	
	13 Dec 82	FB-23	A0 3401	<0.05	<0.10	Trace	morning sample
	13 Dec 82	FB-52	A0 3480	<0.05	<0.10	1.20	afternoon sample
	14 Dec 82	FB-35	--	<0.05	<0.10	--	repeated sample
SP-4	9 Dec 82	SG-06	A0 3061	<0.05	<0.10	0.59	
	10 Dec 82	SG-36	A0 3476	<0.05	<0.10	1.50	
	13 Dec 82	FB-08	A0 3478	<0.05	<0.10	0.18	morning sample
	13 Dec 82	FB-10	A0 3488	<0.05	<0.10	1.3	afternoon sample
	14 Dec 82	FB-42	--	<0.05	<0.10	--	repeated sample
SP-5	9 Dec 82	SG-09	A0 3063	<0.05	<0.10	0.86	
	10 Dec 82	SG-38	A0 3491	<0.05	<0.10	2.60	
	13 Dec 82	FB-24	A0 3399	<0.05	<0.10	Trace	
	13 Dec 82	FB-16	A0 3482	<0.05	<0.10	1.3	morning sample
	14 Dec 82	FB-13	--	<0.05	<0.10	--	afternoon sample
SP-6	9 Dec 82	SG-08	A0 3059	--	--	0.69	repeated sample
	10 Dec 82	SG-33	A0 3073	<0.05	<0.10	1.50	SG-08 broken
	13 Dec 82	FB-31	A0 3409	<0.05	<0.10	ND	
	13 Dec 82	FB-22	A0 3481	<0.05	<0.10	1.20	morning sample
	14 Dec 82	FB-41	--	<0.05	<0.10	--	afternoon sample
SP-7	9 Dec 82	SG-03	A0 3071	<0.05	<0.10	1.30	
	9 Dec 82	SG-12	A0 3069	<0.05	<0.10	1.70	repeated sample

\*1,1-Dimethylhydrazine

+N-Nitrosodimethylamine


\*None detected - value less than 0.05 ug/m<sup>3</sup>§TRACE - value equal to 0.05 to 0.15 ug/m<sup>3</sup>

Sampling Point	Date Sampled	Simultaneous Samples Hyd/UDMA+ Sample No.	Simultaneous Samples NMA+ Sample No.	Hydrazine (in micrograms/cubic meter - ug/m <sup>3</sup> )	Sample Results UDMH	NMA (ug/m <sup>3</sup> )	Remarks
SP-8	9 Dec 82 9 Dec 82	SG-07 SG-18	A0 3058 A0 3070	<0.05 <0.05	<0.10 <0.10	4.20 10.0	
SP-9	9 Dec 82 9 Dec 82 10 Dec 82 13 Dec 82 14 Dec 82	SG-11 SG-34 SG-32 FB-21 FB-12	A0 3064 A0 3068 A0 3490 A0 3411 A0 3427	<0.05 <0.05 <0.05 <0.05 <0.05	<0.10 <0.10 <0.10 <0.10 <0.10	5.50 8.50 3.70 3.40 18.0	
SP-10	9 Dec 82 9 Dec 82 10 Dec 82 13 Dec 82 14 Dec 82	SG-13 SG-16 SG-11 FB-01 FB-40	A0 3072 A0 3060 A0 3479 A0 3406 --	<0.05 <0.05 <0.05 <0.05 <0.05	<0.10 <0.10 <0.10 <0.10 <0.10	1.00 2.50 12.0 0.27 --	repeated sample
SP-11	9 Dec 82 9 Dec 82 10 Dec 82 13 Dec 82 14 Dec 82	SG-14 SG-15 SG-39 FB-02 FB-43	A0 3074 A0 3065 A0 3477 A0 3402 --	<0.05 <0.05 <0.05 <0.05 <0.05	<0.10 <0.10 <0.10 <0.10 <0.10	3.20 20.0 14.0 0.55 --	repeated sample
SP-12	13 Dec 82 14 Dec 82	FB-04 FB-15	A0 3487 A0 3398	<0.05 <0.05	<0.10 <0.10	1.90 0.50	
SP-13	13 Dec 82 14 Dec 82	FB-63 FB-18	A0 3393 A0 3396	<0.05 <0.05	<0.10 <0.10	1.00 4.70	
SP-14	13 Dec 82 14 Dec 82	FB-47 FB-27	A0 3397 A0 3394	<0.05 <0.05	<0.10 <0.10	1.20 0.63	
SP-15	13 Dec 82 14 Dec 82	FB-58 FB-37	A0 3404 A0 3484	<0.05 <0.05	<0.10 <0.10	0.92 1.00	

\*1,1-Dimethylhydrazine  
+N-Nitrosodimethylamine

Sampling Point	Date Sampled	Simultaneous Samples Hyd/UDMA* Sample No.	Simultaneous Samples NDMA* Sample No.	Hydrazine (in micrograms/cubic meter - ug/m <sup>3</sup> )	Sample Results UDMH	NDMA (in micrograms/cubic meter - ug/m <sup>3</sup> )	Remarks
SP-16	13 Dec 82	FB-45	A0 3392	<0.05	<0.10	1.10	
	14 Dec 82	FB-36	A0 3483	<0.05	<0.10	0.62	
SP-17	14 Dec 82	FB-33	A0 3413	<0.05	<0.10	Trace	
	14 Dec 82	FB-59	A0 3417	<0.05	<0.10	0.16	
SP-18	14 Dec 82	FB-39	A0 3412	<0.05	<0.10	0.62	
	14 Dec 82	FB-17	A0 3416	<0.05	<0.10	0.24	
SP-19	14 Dec 82	FB-06	A0 3415	<0.05	<0.10	0.17	
	14 Dec 82	FB-28	A0 3418	<0.05	<0.10	0.50	
SP-20	13 Dec 82	FB-49	A0 3395	<0.05	<0.10	1.20	
	14 Dec 82	FB-29	A0 3400	<0.05	<0.10	0.92	
SP-21	9 Dec 82	SG-04	A0 3057	<0.05	<0.10	1.10	repeated sample
	9 Dec 82	SG-19	A0 3062	<0.05	<0.10	1.40	
	10 Dec 82	SG-46	A0 3473	<0.05	<0.10	1.00	
	13 Dec 82	FB-44	A0 3405	<0.05	<0.10	1.10	
SP-22	14 Dec 82	FB-46	--	<0.05	<0.10	--	repeated sample
	9 Dec 82	SG-20	A0 3067	<0.05	<0.10	Trace	
	9 Dec 82	SG-17	A0 3056	<0.05	<0.10	ND	
	10 Dec 82	SG-35	A0 3472	<0.05	<0.10	0.94	
SP-FH	13 Dec 82	FB-20	A0 3408	<0.05	<0.10	0.12	repeated sample
	14 Dec 82	FB-65	--	<0.05	<0.10	--	
	9 Dec 82	SG-05	A0 3075	<0.05	<0.10	ND	
	10 Dec 82	SG-51	A0 3474	<0.05	<0.10	ND	
	14 Dec 82	FB-05	--	<0.05	<0.10	--	repeated sample

\*1,1-Dimethylhydrazine  
+N-Nitrosodimethylamine


Sampling Point	Date Sampled	Simultaneous Samples		Sample Results		Remarks
		Hyd/UDIA* Sample No.	NMA+ Sample No.	Hydrazine (in micrograms/cubic meter - ug/m <sup>3</sup> )	UDIA NMA	
SP-HQ	10 Dec 82	SQ-55	A0 3485	<0.05	<0.10	repeated sample
	13 Dec 82	FB-25	A0 3403	<0.05	<0.10	
	14 Dec 82	FB-32	--	<0.05	<0.10	
	<div> RODOLFO B. GIOVANNI CPT, HSC Chief, Chromatographic Analysis Branch Organic Environmental Chemistry Division</div>					

\*1,1-Dimethylhydrazine  
+N-Nitrosodimethylamine

TABLE F-2. RESULTS OF WIPE SAMPLES FOR HYDRAZINE AND UNSYMMETRICAL DIMETHYL-HYDRAZINE

Sample Number	Location	Results (in micrograms-total)	
		Hydrazine	UDMH*
W-100	Electrical control panel (west fence)	<5	0.2
W-101	Ground wipe, Drum Steamout (SP-8)	<5	<0.2
W-102	Electrical outlet north of Tank HAS-1	<5	0.3
W-103	Desktop and telephone inside Building 759	<5	<0.2
W-104	Empty barrel storage south of SP-21	<5	<0.2
W-105	Gauges and piping around sump pump at Waste Sump	<5	<0.2
W-106	Control Panel (SP-9)	<5	6
W-107	Water Sample from Waste Sump	<5	<0.2
W-108	Drum loading station (wipe of drum filling nozzles/connectors)	3,475	19.0
W-109	Tank HAS-2, drain valve (Tank pit valve)	<5	<0.2
W-110	Tank HAS-1, control valve (on top)	broken	
W-111	Tank Truck Station, Truck loading filler nozzle and boom	broken	

\* UDMH - 1,1-Dimethylhydrazine.

  
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 Chief, Chromatographic Analysis  
 Branch  
 Organic Environmental Chemistry  
 Division



Ind Hygiene Sp Study No. 55-35-0125-83, 7-17 Dec 82

TABLE F-3. RESULTS OF ANALYSES OF QUALITY CONTROL SAMPLES FOR  
N-NITROSODIMETHYLAMINE SUBMITTED BY ROCKY MOUNTAIN ARSENAL TO  
THERMO ELECTRON CORPORATION,\* ANALYTICAL INSTRUMENT DIVISION,  
WALTHAM, MASSACHUSETTS

Quality Control Sample No.	Date of Sample Preparation	Sample Number	Results	Theoretical Value
QC-1	10 Dec 82	A0 3421	0.84	0.83
QC-2	10 Dec 82	A0 3424	0.91	0.83
QC-3	9 Dec 82	A0 3221	0.96	0.83
QC-4	9 Dec 82	A0 3420	0.84	0.83
QC-5	13 Dec 82	A0 3220	1.00	0.83
QC-6	13 Dec 82	A0 3423	0.69	0.83
QC-7	14 Dec 82	A0 3222	0.80	0.83
QC-8	14 Dec 82	A0 3419	0.76	0.83

\* Thermo Electron Corporation, Analytical Instruments, 101 First Avenue, P.O.  
Box 459, Waltham, Massachusetts.